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Sustainable concrete in Asia: Approaches and barriers considering regional context

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HIGHLIGHTS

- We propose that sustainability of concrete should consider regional context.
- Studies in Asian countries with a variety of conditions were summarized.
- Economic and technology level are important regional factors related to concrete.
- Other factors include institutional systems, stakeholders, and social factors.
- Resource availability, recycling, climate and geography also have an effect.

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ABSTRACT

Asia is home to a diversity of socio-economic and environmental conditions which directly affect concrete-related manufacturing and construction. The implementation of sustainable concrete in Asian countries is thus highly dependent on their regional conditions, but the regional context of sustainable concrete needs to be understood in order to connect generalized strategies with actual implementation. This paper summarizes the results and key findings from previous qualitative investigations carried out in Japan, Thailand, S. Korea, Mongolia, and Singapore, and compares the approaches and barriers to sustainable concrete in order to extract regional issues and their relationship with sustainable concrete. The results highlight the importance of institutional systems, economic factors, resource availability and recycling, geography and climate, technology level, stakeholder roles and relations, and social factors when considering the implementation of strategies for sustainable concrete in Asia.

1. Introduction

Increased awareness of sustainable development has led the concrete industry to consider a practical interpretation of sustainability and climate change mitigation actions targeted at construction activities [8]. Within the concrete industry, discussions on sustainability have generally focused on the short- and long-term environmental impacts of concrete materials, construction, and structures, with particular emphasis on the large-scale emissions of greenhouse gases and particulate matter, massive consumption of natural resources such as water, sand and aggregates, and widespread waste generation from demolished concrete structures [9,10,12].

In order to implement sustainable practices across all phases of the concrete life cycle, there have been a variety of actions taken at the national or multi-national levels. Some examples include the Concrete Joint Sustainability Initiative in North America, the Concrete Industry Sustainable Construction Strategy in the United Kingdom, and the Nordic Network "Concrete for the Environment." The Joint Sustainability Initiative was established to support and coordinate the actions of industry stakeholders towards improving sustainability in the North American concrete industry [1], whereas the member countries of the Nordic Network chose to face environmental challenges in different ways: Denmark established a center for green concrete, while Norway developed an online, comprehensive database of important documents [4].

However, while construction investment may be stabilizing in many developed countries, demand for and production of concrete-making materials is projected to grow in developing countries, particularly in Asia [12]. Considering this growth – and the accompanying increase in negative environmental impacts – the Asian Concrete Federation (ACF) established a Sustainability Forum with representatives from a wide variety of countries, including India, Indonesia, Japan, S. Korea, Mongolia, Taiwan, and Vietnam, to tackle sustainability-related issues in Asia and to pursue the

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goals laid out in the 2010 ACF Taipei Declaration on Sustainability. This declaration includes six items: recognizing the importance of the Asian concrete society's role in achieving sustainable development; realizing the need for sustainable development by reducing resource consumption and carbon footprint; encouraging the concrete industry to provide safe, serviceable, and environmentally-friendly structures for the good of society; promoting the use of the best technologies and technological innovations for sustainability; informing the concrete industry and the public of the role concrete plays in sustainable development; and collaborating with other international associations towards the goal of sustainable development [2].

While ACF is moving towards a general framework for the Asian region, the actual implementation of sustainable strategies will necessarily vary between countries or regions. The concept of "regional context" can be derived from the United Nation's description of sustainability as being built upon the "interdependent and mutually reinforcing" social, economic and environmental pillars [13]: that is, strategies or activities which may be sustainable in one region of the world under a given set of social, economic, and environmental conditions may not be sustainable in a different region of the world under different conditions. For the concrete industry, materials, construction, and structures are often region-specific and depend on climate, geography, availability of resources, level of development and technology, transportation and shipping systems, construction culture and stakeholders, and governing systems. These factors vary widely – particularly in Asia, which has a diverse range of conditions – and thus the regional implementation of strategies for sustainable concrete will also vary.

In order to understand region-specific issues related to concrete sustainability, investigations have been carried out in several Asian countries [5–7]. These investigations, which covered Japan, Thailand, South Korea, Mongolia, and Singapore (Fig. 1), sought to clarify the conditions in each country's concrete industry and relate those conditions to the strategies for sustainable concrete based on the perspectives of a diverse group of interviewed stakeholders. These five countries represent a wide range of development levels, climates, geographies, institutional systems, available resources, construction cultures, technology levels, and so forth (Table 1), and while their comparison is not indicative of Asia as a whole, it can provide some insights into the regional context of sustainable concrete.

This paper begins by presenting an overview of the general results and key findings from the previously conducted studies in Japan, Thailand, S. Korea, Mongolia and Singapore. It then focuses on and discusses the approaches to sustainable concrete and barriers to moving towards sustainability in the Asian concrete industry in the context of a broad range of regional conditions.

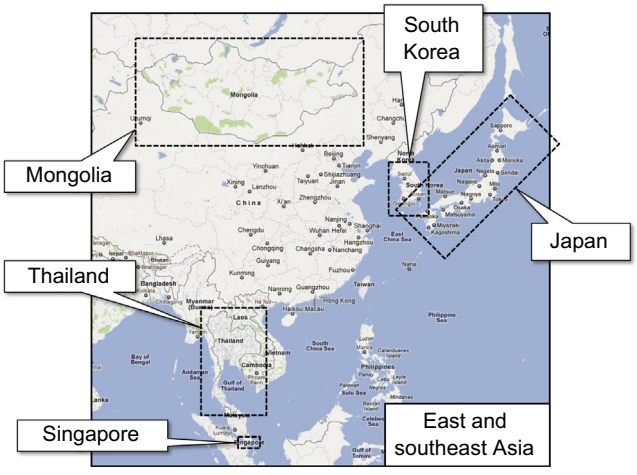

Fig. 1. Geographic location of investigated countries.

2. Research methodology

2.1. Interview contents and objectives

Conditions in the target countries' concrete industries were qualitatively investigated using in-depth, semi-structured interviews with a variety of industry stakeholders in each country. These semi-structured interviews followed a general outline but allowed for areas of interest to be explored in further detail [11]. The interview contents used in the investigations covered three main areas, as summarized in Table 2, with the objective of understanding the regional differences in industry conditions and general sustainability issues, concept of sustainable concrete practice and materials, and barriers to implementing those practices and materials.

2.2. Interview sample

Over the course of the five investigations interviews were carried out with 42 people. The distribution of interviewees by general stakeholder groups is given in Table 3. The owner group includes representatives from government agencies, infrastructure developers, and real estate developers. Material interviewees came from cement manufacturers, ready-mix concrete producers, chemical manufacturers, and pre-cast producers. These interviewees were selected through professional contacts, with a focus on experts involved in the development, usage, and management of concrete so that general issues and their regional context could be identified. While some stakeholders groups were not represented in the original studies, their situations could be understood to some extent through their interactions with other stakeholders.

3. Key findings from previous investigations

3.1. Japan

In Japan, the importance of durability for sustainable concrete was repeatedly emphasized in the investigation, which can be understood in the context of a decreasing and aging workforce with decreasing natural and economic resources. In addition, as the efficiency level of the Japanese cement industry is already high, enhancing durability is one strategy to reduce transportation- and construction-related CO_2 emissions. The importance of recycling in Japan could also be understood not as a means to further reduce waste generation, as Japan already enjoys a 96% recycling rate for concrete, but rather as a means for reducing the consumption of natural resources by utilizing recycled concrete as raw material in new construction instead of down-cycling it as backfill. Barriers to the implementation of sustainable concrete practice and materials may be the most specific to Japan's conditions.

3.2. Thailand

Thailand represents a unique case for sustainable concrete due to widespread adoption of fly ash concrete, which contributes to reducing the environmental impact of concrete materials. Investigation results found that, due to the low cost of labor, price serves as the most important criteria for concrete, which makes it difficult to test or adopt new technologies due to high cost competition. Most technology is diffused through the cement companies, which have the highest investment in R&D, although foreign consultants also provide such support. Finally, the lack of sustainability education makes it difficult to convince customers of additional value such as environmental impact reduction – thus education should form the base of promoting sustainable practice. Since environmental technologies cannot compete on cost, criteria for additional value are also necessary to concretely evaluate these characteristics.

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